(12) UK Patent Application (19) GB (11) 2 228 379(13) A

(43) Date of A publication 22.08.1990

(21) Application No 9000641.2

(22) Date of filing 11.01.1990

(30) Priority data
(31) 0191 (32) 13.01.1989 (33) FI

(71) Applicant
Telenokia Oy

(Incorporated in Finland)

P.O. Box 33, SF-02601 Espoo, Finland

(72) Inventors
Jarmo Makinen
Reino Talarmo

(74) Agent and/or Address for Service
Frank B Dehn & Co
Imperial House, 15-19 Kingsway, London, WC2B 6UZ, United Kingdom

(51) INT CL[5]
H04B 1/38, H03D 7/12

(52) UK CL (Edition K)
H3A AB
H4L LECF L1H1D L1H7B
U1S S1912

(56) Documents cited
GB 1518831 A1 GB 1439895 A EP 0171997 A1
EP 0135816 A2 WO 85/02734 A1

(58) Field of search
UK CL (Edition J) H3A AB, H3R RFDX RFMR, H4L LECF LECX
INT CL[4] H03D 3/00 7/00 7/12 7/14 7/16 7/18, H03L 7/24, H04B 1/38 1/50 1/54 1/56 1/62

(54) Frequency-modulated transceiver

(57) A frequency-modulated transceiver in which modulation caused by the transmitter part of the transceiver in the output signal of the receiver i.f.-mixer is decreased. The transmitter comprises a frequency-modulated high-frequency oscillator (1) having a modulation input and an output, and the receiver comprises in a cascade: a high-frequency mixer (9) having a local oscillator input functionally connected to the output of the high-frequency oscillator (1) of the transmitter; a first intermediate filter (8); and an intermediate frequency mixer (7). The receiver further comprises a frequency-modulated local oscillator (4) having an output functionally connected to a local oscillator input in the intermediate frequency mixer (7), the local oscillator being modulated with the modulating signal of the transmitter. Modulation caused by the transmitter part of the transceiver in the output signal of the intermediate frequency mixer is decreased by time-delay means (3) connected in series with the local oscillator (4) before or after it, the time-delay means (3) compensating for the time difference between the modulation of the local oscillator signal of the intermediate frequency mixer (7) and the modulation caused by the transmitter part in the input signal of the intermediate frequency mixer (7).

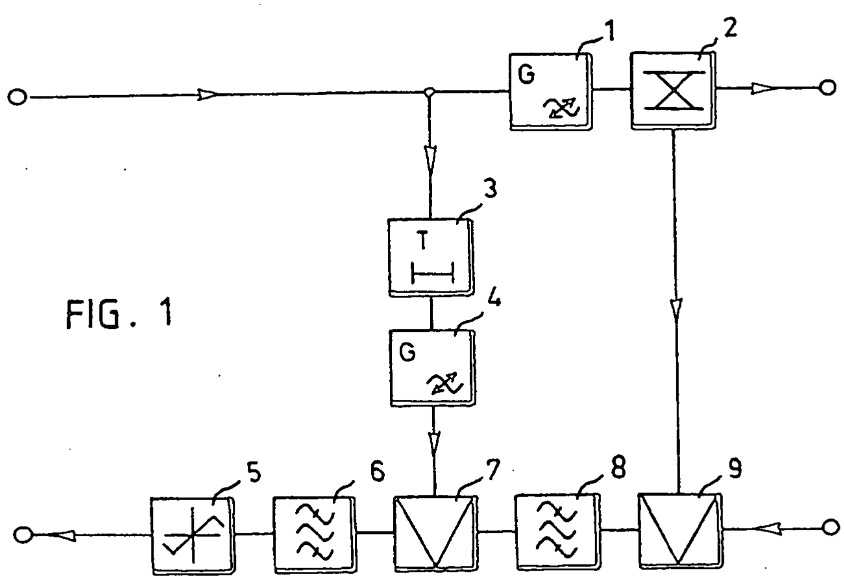

FIG. 1

1/1

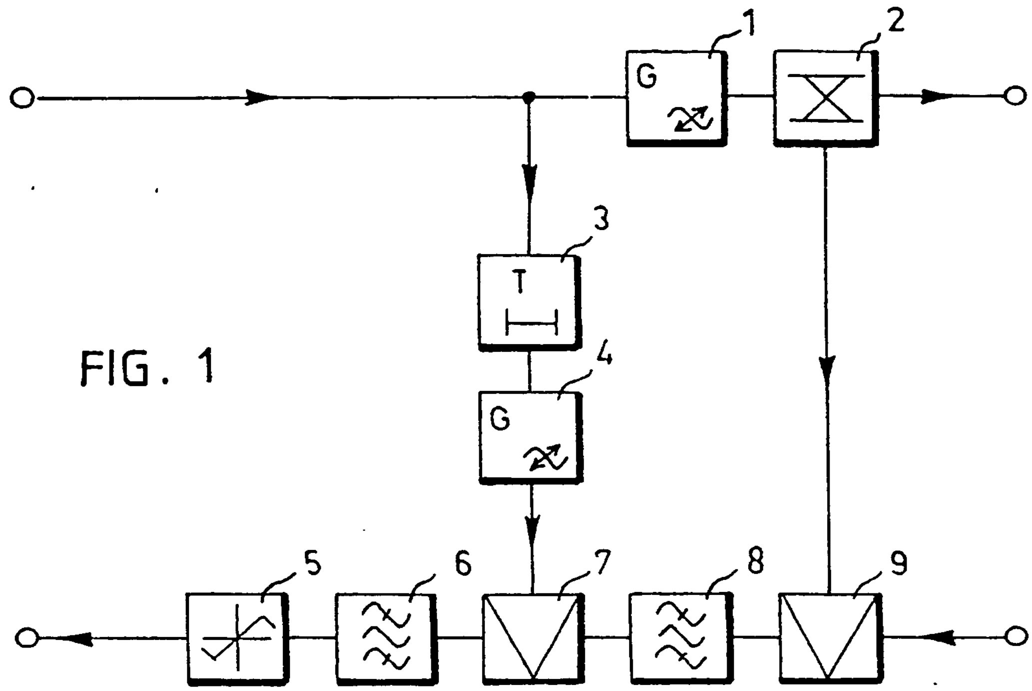

FIG. 1

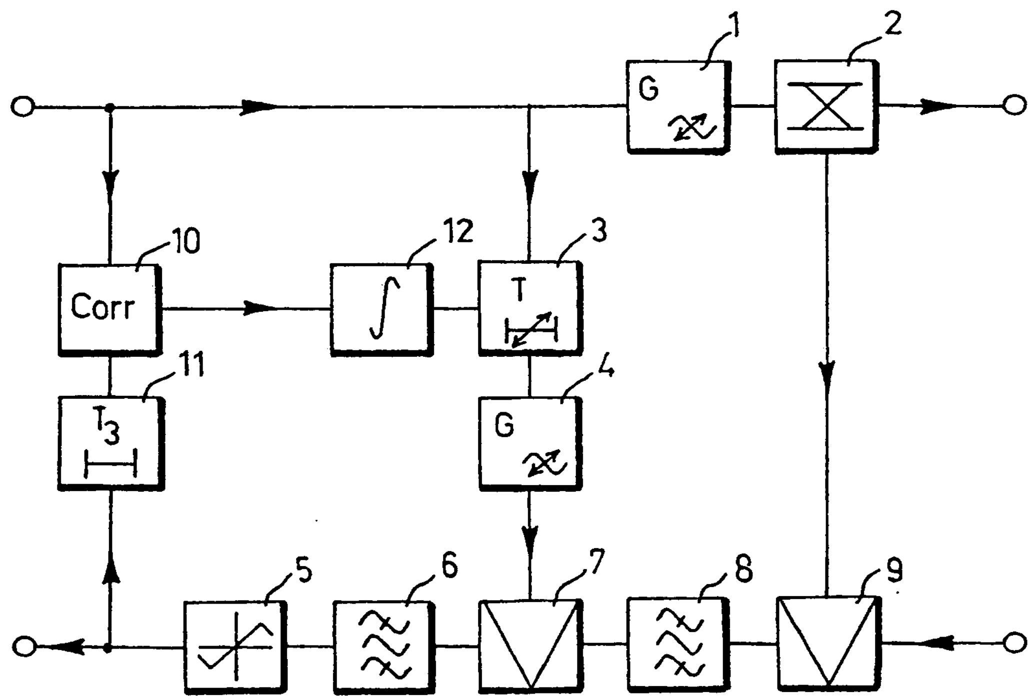

FIG. 2

Frequency-modulated transceiver

The invention relates to a frequency-modulated transceiver in which the transmitter comprises a frequency-modulated high-frequency oscillator having a modulation input and an output, and the receiver comprises in a cascade: a high-frequency mixer having a local oscillator input functionally connected to the output of the high-frequency oscillator of the transmitter; a first intermediate filter; and an intermediate frequency mixer; the receiver further comprising a frequency-modulated local oscillator having an output functionally connected to a local oscillator input in the intermediate frequency mixer, the local oscillator being modulated with the modulating signal of the transmitter.

Particularly in radio devices operating within the microwave range (> 1 GHz), such as radio links, it is preferable to minimize the number of high-frequency and microwave components, since these are not only the most expensive but also in many cases the most critical components in the system.

In a prior art solution, the receiver part of the transceiver does not comprise any high-frequency local oscillator as the local oscillator signal of the high-frequency mixer of the receiver is produced from the frequency-modulated output signal of the transmitter part. The first intermediate frequency signal of the receiver thereby contains both the received signal and the modulation of the transmitter part. The modulation of the transmitter part is compensated for in the intermediate frequency mixer, the frequency-modulated local oscillator of which is modulated directly with the modulating signal of the transmitter. The detected signal should thereby be

free from so called residual modulation caused by the transmitter part.

In practice, however, there occurs residual modulation in the detected signal, which increases the bit error ratio in the case of a digital signal (PCM signal). The amount of residual modulation increases with increasing transmission rate, making the reception impossible at higher transmission rates. So this prior art solution can be applied only at relatively low transmission rates.

These problems are avoided according to the invention by means of a transceiver of the type described above and characterized in that a time-delay means is connected in series with the local oscillator before or after it, the time-delay means compensating for the time difference between the modulation of the local oscillator signal of the intermediate frequency mixer and the modulation of the transmitter part in the input signal of the intermediate frequency mixer.

The invention is based on the Applicant's observation that an important factor in the formation of residual modulation is that the modulation of the local oscillator signal of the intermediate frequency mixer and that caused by the transmitter part in the input signal of the intermediate frequency mixer deviate from the desired simultaneity. This time difference is due to the time delay caused particularly by the high-frequency modulator of the transmitter and the first intermediate frequency filter of the receiver and the transmission line between them. This time delay is to some extent compensated for by the phase shift caused by the local oscillator. However, the time difference is sufficient to cause residual modulation in the detected signal. The amount of the residual modulation

caused by the time difference as well as its effect on the detected digital signal increases with increasing transmission rate. The time-delay means according to the invention compensates for this time difference, eliminating the residual modulation caused by it, wherefore the transmission rate of the transceiver of the invention is not restricted (transmission rates as high as 140 Mbit/s are possible). In addition, the operating properties of the transceiver are improved also at lower transmission rates.

The invention will now be described in greater detail by means of exemplary embodiments and with reference to the attached drawing, in which

Figure 1 is a block diagram of a transceiver comprising a phase shift means according to the invention; and

Figure 2 is a block diagram of another transceiver in which the phase shift means is adaptively adjustable.

In the transceivers of Figures 1 and 2, the modulating signal of the transmitter is applied to a modulation input in a frequency-modulated high-frequency oscillator 1. From the output of the high-frequency oscillator 1 a frequency-modulated signal at the transmission frequency is applied through a branching means 2 either directly or possibly through a high-frequency amplifier (not shown) to an antenna. The modulating signal is preferably a digital signal. As used herein, the term "high-frequency" refers particularly but not only to microwave frequencies (> 1 GHz).

The receiver comprises a series connection of the following components in this order: a high-frequency mixer 9, a first intermediate frequency filter

8, an intermediate frequency mixer 7, a second intermediate frequency filter 6, and a detector 5. The received signal is applied from the antenna to the mixer 9, to the local oscillator input of which the frequency-modulated output signal of the oscillator 1 is applied through the branching means 2. The mixer 9 thereby shifts the received signal to a first intermediate frequency, simultaneously adding to it the modulation present in the output signal of the oscillator 1. The intermediate frequency output signal of the mixer 9 is bandpass filtered by means of the first intermediate frequency filter 8 and applied to the intermediate frequency mixer 7.

The output signal of a frequency-modulated local oscillator 4 is applied to the local oscillator input of the mixer 7. The modulating signal of the transmitter is applied through the time-delay means 3 to the modulation input of the oscillator 4. The oscillator 4 is thus modulated with the same modulating signal as the oscillator 1 of the transmitter. As a result, the modulation present in the local oscillator signal of the mixer 7 is equal to and has equal phase as the modulation caused by the transmitter part present in the input signal of the mixer 7. In principle, the mixer 7 thereby eliminates the modulation caused by the transmitter part when it shifts the received signal to a second intermediate frequency. The output of the mixer 7 is bandpass filtered by means of the second intermediate frequency filter 6, and detected with the detector 5. There should not occur any residual modulation caused by the transmitter part in the output signal of the detector 5.

The propagation time delay of the signal from the input of the oscillator 1 through the

oscillator 1, the branching means 2, the mixer 9, the first intermediate frequency filter 8 and the transmission lines between them to the input of the mixer 7 exceeds the propagation time delay of the signal from the input of the oscillator 1 through the local oscillator 4 to the local oscillator input of the mixer 7. This causes a time difference to occur between the modulation of the local oscillator signal of the mixer and the modulation caused by the transmitter part in the input signal of said mixer.

This time difference is compensated for by means of the time-delay means 3, connected in series with the oscillator 4. The delay of the time-delay means 3 is selected so that the propagation times of the above-mentioned signal paths are substantially equal.

The time-delay means 3 may be positioned before the oscillator 4 or after it, and it may be fixed or manually adjustable (as in Figure 1) or adaptively adjustable (as in Figure 2).

Figure 2 shows a correlator 10 having one input connected to the input of the oscillator 1 and the other input through a time-delay means 11 to the output of the detector 5. The output of the correlator 10 is connected through an integrating or averaging means 12 to an adjustable input in the adjustable time-delay means 3. The correlator 10 correlates the detected signal and the modulating signal of the transmitter with each other, controlling the amount of the time delay caused by the time-delay means 3 in response to the correlation result so that the correlation decreases, that is, the residual modulation occurring in the detected signal is decreased. The time delay caused by the time-delay means 11 and the intermediate frequency filters 6 and 8, of the order

of about half a signal pulse, makes it easier to carry out the correlation.

An advantage of adaptive adjustment is that it responds automatically to changes in the propagation time delay caused, e.g., by varying transmission line lengths.

The attached figures and the description related thereto are only intended to illustrate examples of the present invention. In its details, the transceiver according to the invention may vary within the scope of the attached claims.

Claims

1. A frequency-modulated transceiver in which the transmitter comprises a frequency-modulated high-frequency oscillator having a modulation input and an output and the receiver comprises in a cascade: a high-frequency mixer having a local oscillator input functionally connected to the output of the high-frequency oscillator of the transmitter; a first intermediate filter; and an intermediate frequency mixer; the receiver further comprising a frequency-modulated local oscillator having an output functionally connected to a local oscillator input in the intermediate frequency mixer, the local oscillator being modulated with the modulating signal of the transmitter, characterized in that a time-delay means is connected in series with the local oscillator before or after it, the time delay means compensating for the time difference between the modulation of the local oscillator signal of the intermediate frequency mixer and the modulation of the transmitter part in the input signal of the intermediate frequency mixer.

2. A transceiver according to claim 1, characterized in that the time-delay means is connected on the path of the modulating signal of the transmitter before the input of the local oscillator.

3. A transceiver according to claim 1 or 2, wherein a second intermediate frequency filter and a detector are connected in series after the intermediate frequency mixer, characterized in that the time-delay means is adaptively adjustable in response to the residual modulation occurring in the output signal of the detector.

4. A transceiver according to claim 3, characterized in that it comprises a correlation means for correlating the modulating signal of the transmitter

part and the output signal of the detector with each other, the amount of the time delay produced by the time-delay means being varied in response to the correlation result so as to minimize the correlation between said signals.

5. A transceiver according to claim 4, characterized in that another time-delay means is connected between the output of the detector and one input in the correlation means.

6. A transceiver substantially as hereinbefore described with reference to Fig. 1 or Fig. 2 of the accompanying drawings.

Published 1990 at The Patent Office, State House, 66/71 High Holborn, London WC1R 4TP. Further copies may be obtained from The Patent Office
Printed by Multiplex techniques ltd. St Mary Cray, Kent. Con. 1/87